Thermodynamics

(B145)

High Speed Flow, have a high energy, or a great deal of energy.

→ Has a lot of Kinetic Energy & Thermal Energy.

→ looking at flows above 100 m/s.

→ Changes in one or the other will result in corresponding changes.

1st Law of Thermodynamics.

- For any ~~system~~ ~~defiantl~~ defiantly of gas

the energy per unit mass can only change through

a) heat being added to or taken from system by the surroundings.

b.) work being done on the system or by the system.

dx ← perfect differential or definite derivative

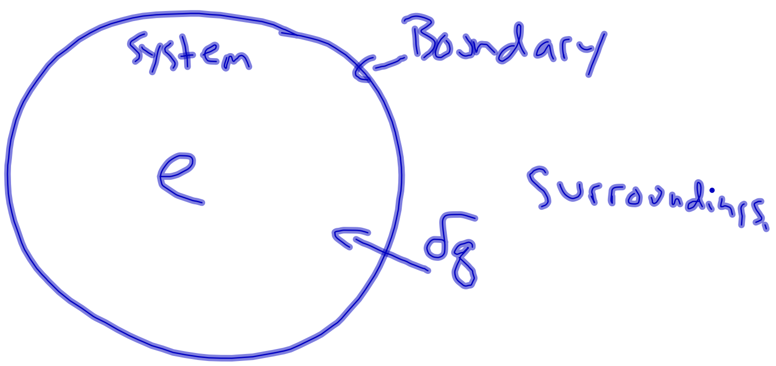
δx ← partial or other derivative.

δq = change in heat per unit mass

δw = work done on (by) system per unit mass

de = change in internal energy per unit mass

$$\boxed{de = \delta q + \delta w}$$ 1st Law of Thermo.



Look at some element of the system

dx ~ compression distance of boundary Area dA

i.e. we're looking at a change in volume.

compressible Flow.

Pressure being applied on the boundary element dA

$\therefore$ Work is being done on the system.

$\left(p = \frac{F}{A}\right)$ $\quad W = F\Delta x$

$F = p\,dA$ $\quad = p\,dA(\Delta x)$

$$\delta w = \int p\,dA \cdot s \qquad \Delta x = s$$

= small displacement due to pressure

$$= \int p \cdot s\,dA$$

i.e. work done on the system is essentially due to looking at all the pressures being applied over the entire boundary.

- BUT, not exactly equivalent yet since $\delta w = \frac{\text{work}}{\text{unit mass}}$

$$\delta w = \int p \cdot s\,dA$$

$\Rightarrow$ assume a constant P. (isobaric)

$$\delta w = p \underbrace{\int_A s\,dA}_{\text{over some Area.}}$$

looking @ the change in volume

$\Rightarrow$ $s\,dA$ = Change in volume

$\Rightarrow$ change in volume / unit mass

$= dv \leftarrow$ specific volume

$= dv$

$$\delta w = -p\,dv \quad \left(v = \frac{1}{\rho}\right)$$

pressure

specific volume (density)

1st Law eq.s.

$$\begin{cases} de = \delta w + \delta q \\ de = \delta q - p\,dv \\ \delta q = de + p\,dv \end{cases}$$

Enthalpy $= h$

= a measure of heat transfer for constant pressure (isobaric) problems.

$$h = e + pv \quad \left(\begin{array}{c} \text{from } p = \rho RT \\ pv = RT \\ \text{for Perfect Gases} \end{array} \right)$$

$$dh = de + pdv + vdp$$

$$de = dh - \cancel{pdv} - vdp$$

$$= \delta q - \cancel{pdv}$$

$$\boxed{\delta q = dh - vdp}$$

→ Another 1st Law.

Looking at 1st Law

$$de = \delta q + \delta w$$

$$de = \delta q - p\,dv$$

$$\delta q = dh - v\,dp$$

For systems, we're really looking at P, v, T (ρ) and the processes by which they change.

Two basic processes are
constant volume (P, T changes)
and
constant pressure (v, T (ρ) changes)

So it must be known what process is occurring in order to treat system accordingly.

Specific Heat

= heat added or subtracted from system per unit change in Temperature.

$$C = \frac{\delta q}{dT}$$ ← change in heat per unit mass

* Not a constant
→ varies depending upon process.

$$C_p = \left(\frac{\delta q}{dt}\right)$$ constant pressure.